DRAFT

60618

Anorthosite in Impact-melt

21.7 grams

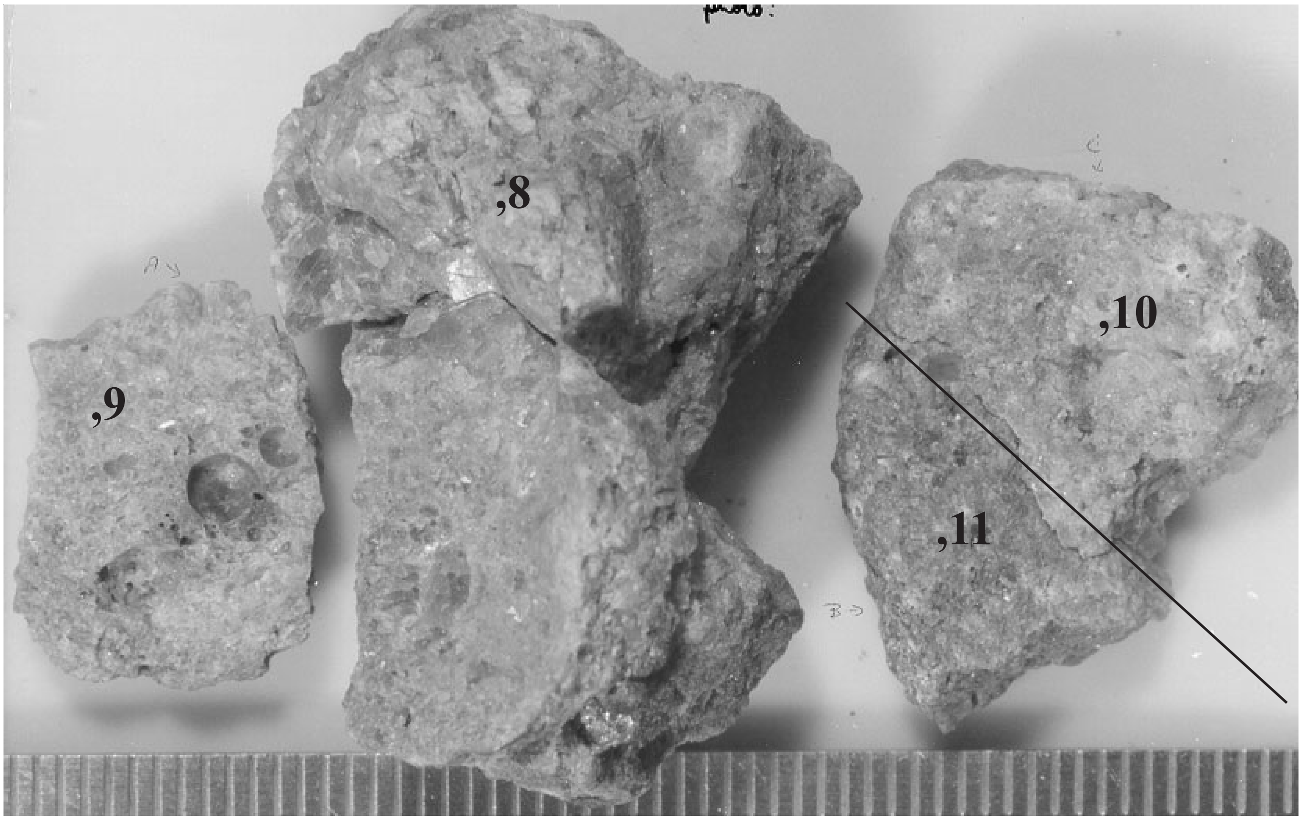

Figure 1: Photo of 60618. These three pieces fit together. Large round veiscles (4 mm) are prominant on the backside of center piece. Large pieces of plagioclase (anorthosite ,10) were surrounded by melt rock (,11). NASA S73-20462. Scale in mm.

Introduction

60618 is a rake sample collected close to the Lunar Module (Butler 1972). The research is summarized in Ryder and Norman (1980). It contains large plagioclase crystals in a grey matrix with prominent vesicles (figure 1). It was found to be highly aluminous with an age about 4 b.y.

Petrography

Dowty et al. (1974a, b) and Keil et al. (1975) found that there were two lithologies to 60618 (anorthosite and impact-melt rock). The impact-melt rock portion contains many relatively large equant (0.5 mm) plagioclase grains (which are relicts) and plagioclase needles (up to 0.5 mm) which crystallized from the melt. The plagioclase is ~An_{95}. Irregular olivine (Fo_{76-84}) and pyroxene (figure 5) subophitically enclose the plagioclase. Minor phases include ilmenite, armalcolite, nickel-iron metal, schreibersite and troilite.

The coarse-grained anorthosite (figure 2) is described as an "anorthosite" by Dowty et al. (1974) or "spinel-olivine anorthosite" by Warner et al. (1976) although it was made up of a single large plagioclase grain which has included olivine and pyroxene grains that are more Mg-rich than for most ferroan anorthosite (figures 3 and 4). Also, the trace element pattern is not that of an anorthosite (figure 6).

Keil et al. (1975) performed a mixing model calculation to show that the melt rock portion could be a mixture of KREEP and anorthosite.

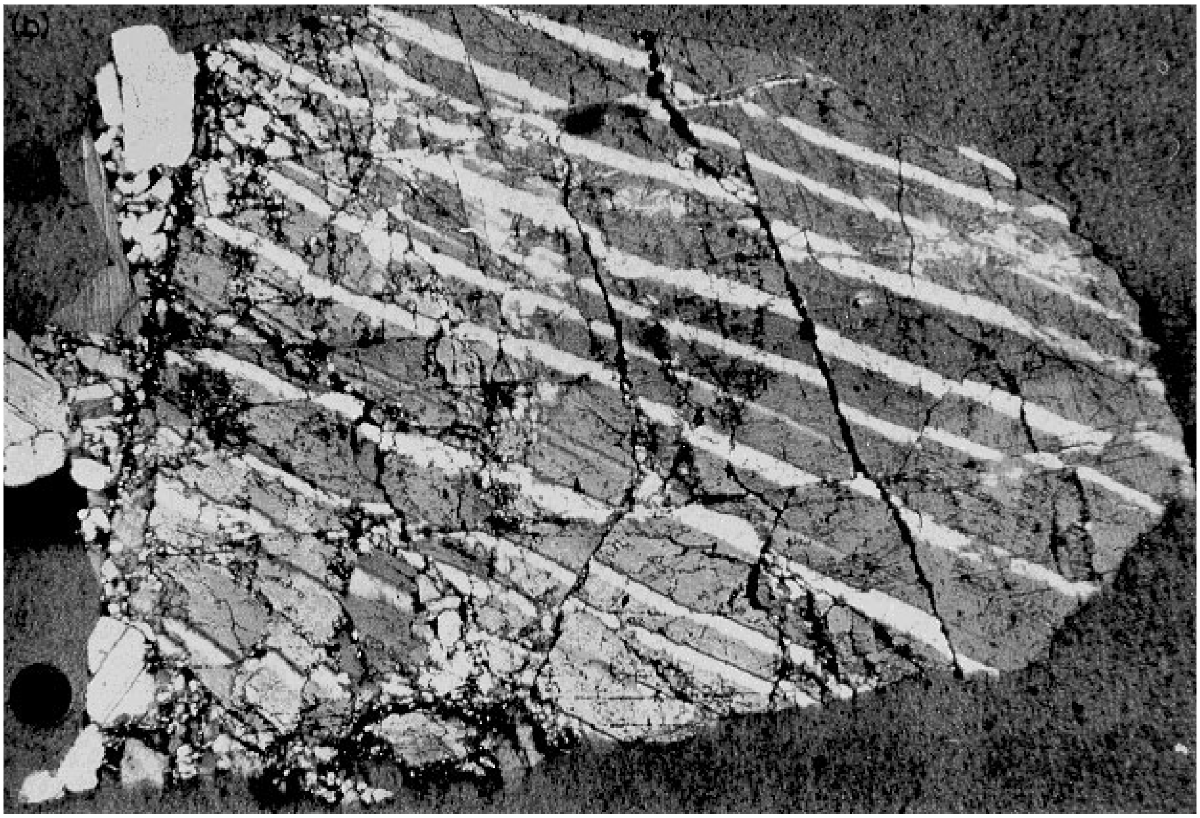

Figure 2: Large shocked and twinned plagioclase grain from 60618 (Dowty et al. 1974). Width of field is 4 mm.

Mineralogy

Olivine: Olivine in the anorthositic portion is 60618 is Fo_{83-85} while it has a range Fo_{76-84} in the "basaltic-textured" impact-melt region (Dowty et al. 1974a, Keil et al. 1975).

Pyroxene: The pyroxene in both the "anorthositic" portion and "melt-rock" portion is rather mafic (figures 4 and 5).

Plagioclase: Plagioclase is An_{96} (Dowty et al. 1974a). Meyer (1979) determined the trace element content of plagioclase.

Spinel: Minor amounts of Mg-Al spinel were found in the granulated matrix (Dowty et al. 1974a).

Chemistry

Eldridge et al. (1975), Dowty et al. (1974) and Murali et al. (1977) reported chemical analyses (table 1, figure 6).

Radiogenic age dating

Schaeffer and Schaeffer (1977) attempted to date 60618 but it did not provide a clear-cut plateau (figure 7). However, they determined an age of 4.00 ± 0.02 b.y.

Cosmogenic isotopes and exposure ages

Eldridge et al. (1975) determined cosmic-ray induced activity for ^{22}Na = 45 dpm/kg. and ^{26}Al = 170 dpm/kg. Schaeffer and Schaeffer (1977) were unable to determine the cosmic ray exposure age due to excess ^{38}Ar.

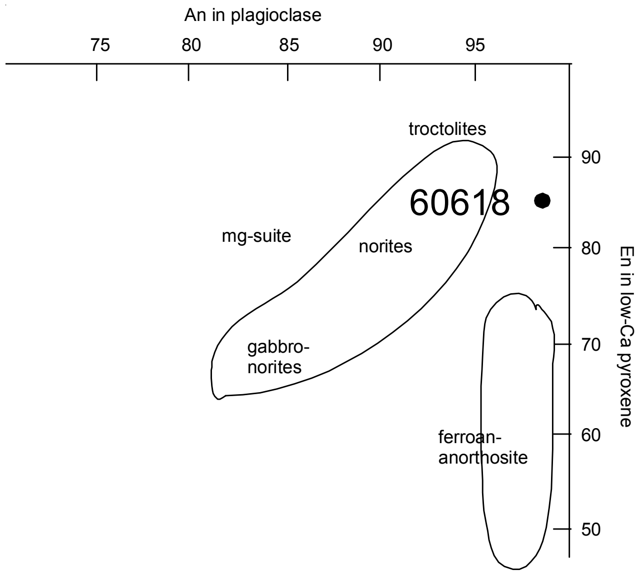

Figure 3: Pyroxene and plagioclase composition of anorthositic portion of 60618 (from Warner et al. 1976).

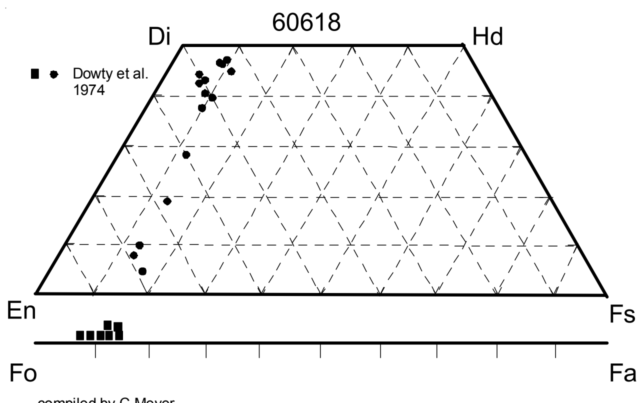

Figure 4: Pyroxene and olivine composition of anorthositic portion of 60618 (from Dowty et al. 1974).

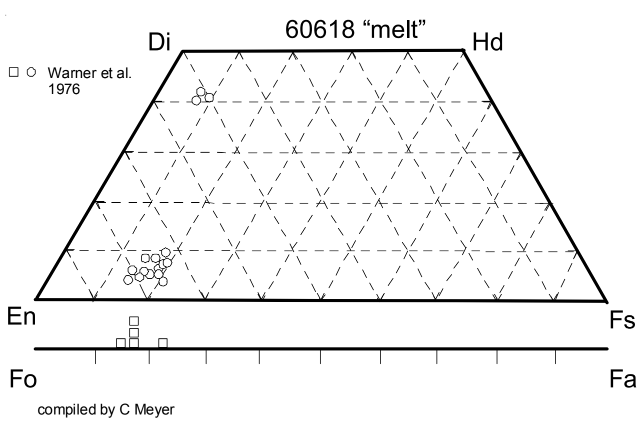

Figure 5: Pyroxene and olivine composition of melt portion of 60618 (from Warner et al. 1976).

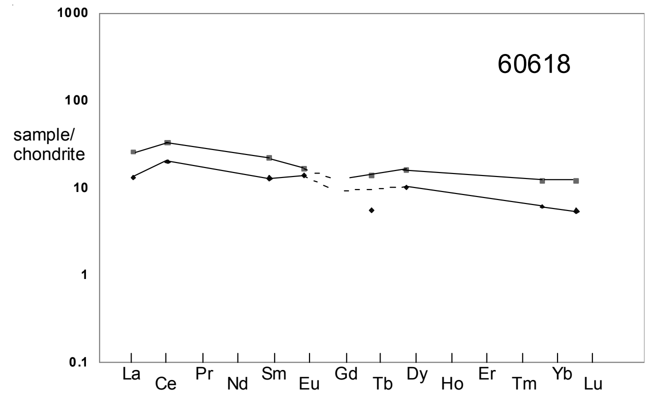

Figure 6: Normalized rare-earth-element pattern of anorthositic portion of 60618 (data from Murali et al. 1978).

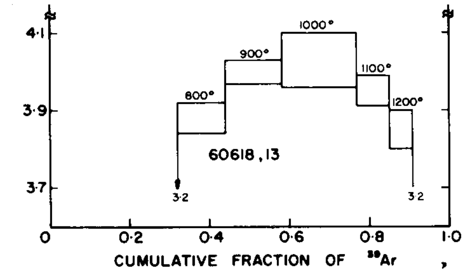

Figure 7: Ar/Ar plateau diagram for 60618 (from Schaeffer and Schaeffer 1977).

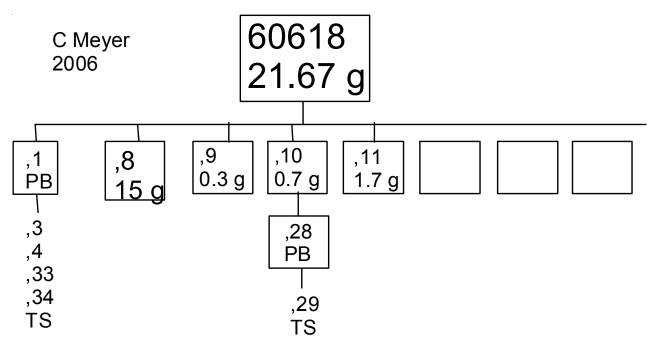

Table 1. Chemical composition of 60618.

			anorthosite			melt rx.		anorthosite		anor	matrix	
reference	Eldridge 75		Murali 78			Dowty 74b		Dowty 74a		Ebihara 92		
weight			,16	,21								
SiO2 %						45.7	(b)	44.2	(b)			
TiO2			0.1	0.3	(a)	0.24	(b)	0.03	(b)			
Al2O3			31.5	29.5	(a)	28.5	(b)	33.6	(b)			
FeO			1.5	2	(a)	2.04	(b)	0.67	(b)			
MnO			0.02	0.03	(a)	0.03	(b)	0.01	(b)			
MgO			4.8	4.1	(a)	5.6	(b)	2.09	(b)			
CaO			16.6	15.7	(a)	16	(b)	18.4	(b)			
Na2O			0.38	0.43	(a)	0.57	(b)	0.39	(b)			
K2O	0.081	(c)	0.045	0.097	(a)	0.21	(b)	0.03	(b)			
P2O5						0.06	(b)	0.03	(b)			
S %												
sum												
Sc ppm			1.5	3.2	(a)							
V			15	16	(a)							
Cr			342	417	(a)	410	(b)	68	(b)			
Co			12	4.1	(a)							
Ni			228	50	(a)					227	47.6	(d)
Cu												
Zn										13.3	22.6	(d)
Ga												
Ge ppb										242	60	(d)
As												
Se										42.4	131	(d)
Rb										1.7	8.05	(d)
Sr												
Y												
Zr			41	120	(a)	280	(b)	80	(b)			
Nb												
Mo												
Ru												
Rh												
Pd ppb										12	2.3	(d)
Ag ppb										0.46	0.68	(d)
Cd ppb										41	89	(d)
In ppb												
Sn ppb												
Sb ppb										1.75	1.79	(d)
Te ppb										<1.1	3.3	(d)
Cs ppm										0.074	0.178	(d)
Ba			36	70	(a)							
La			3.2	6	(a)							
Ce			12	20	(a)							
Pr												
Nd												
Sm			1.9	3.2	(a)							
Eu			0.77	0.93	(a)							
Gd												
Tb			0.2	0.5	(a)							
Dy			2.5	4	(a)							
Ho												
Er												
Tm												
Yb			1	2	(a)							
Lu			0.13	0.29	(a)							
Hf			1.4	2	(a)							
Ta			0.15	0.25	(a)							
W ppb												
Re ppb										0.57	0.097	(d)
Os ppb										12.9	1.32	(d)
Ir ppb			5	3	(a)					7.85	1.48	(d)
Pt ppb												
Au ppb				15	(a)					5.36	1.33	(d)
Th ppm	0.63	(c)	0.3	0.9	(a)							
U ppm	0.28	(c)								0.217	0.589	(d)

technique: (a) INAA, (b) broad beam elec. Probe, (c) radiation counting, (d) RNAA